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DEVELOPMENT OF COURSE MODULES FOR MATERIALS EXPERIMENTS

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Key Words: Computer Courseware

Prerequisite Knowledge: Basic math, chemistry and physics for entry-level materials science laboratories, elementary computer skills.

Objective: To enhance learning in materials science laboratories.

Equipment: This courseware is presently Macintosh compatible, although a PC version will be available in the near future. The minimum system configuration is system 7.0 or higher, 4 MB of RAM, and prefers 256 colors.

Introduction:

Recent U.S. government-sponsored studies of the decline of international competitiveness have reported that one of the most severe problems is the lack of education of future engineers in synthesis and processing of advanced engineered materials. In response, the National Science Foundation has made awards to 6 universities to develop materials processing course materials for improving processing education. Iowa State University is among those selected.

Approach:

Development philosophy

A common problem with introducing new course material to an existing curriculum is that most programs are considered to be "over-committed" in terms of course topics and time and have very little flexibility. Few departments can afford the curriculum space to introduce an entirely new course in their program, and therefore must depend on introducing new or expanded material in the framework of the already existing courses. Since there is an outstanding variety of programs which include materials science and processing, flexibility is the key. In order to ensure that the materials developed at ISU can benefit the maximum number of students in Materials Science and Engineering, a new approach was developed.

A system involving flexible teaching modules has been designed to respond to the varying needs of existing departments, including that at Iowa State University. Each module is a 4-6 week set of teaching lectures and laboratories which can be used individually or together. This approach addresses the needs not only of the education of students majoring in the field of

materials science and engineering, but also in allied disciplines either in the form of service courses taught to non-majors, or materials-related courses taught by other departments.

Computer-based course development was selected as a mode of delivery largely because of its flexibility. Computer based course material (courseware) can be designed such that the modules emphasizing specific processing techniques share common links to fundamental concepts so that each module can be as complete and concise as possible without repeating common material. Courseware also allows great flexibility in the order of presentation of materials, a significant departure from the traditional linear textbook approach. Also, the user can choose the level of the presentation, from basic to advanced. Delivery of courseware over a national network also provides maximum availability to students and educators. Additionally, courseware provides functionality not easily achieved in "hard copy" form. Specifically, color photographs and images, animations, videos, and sounds are easily accommodated. Finally, courseware can be designed to require interactive learning -- the student is asked to answer questions or provide some sort of input in order to proceed. It has been suggested that active learning is more effective for a majority of students than classical passive learning styles frequently associated with lectures or reading a text. Since this interactive component is particularly well-suited to laboratory exercises, the scope of lab exercises has been expanded to include 9 experiments outside the area of materials processing for use in an introductory materials science class.

Software description

Authorware Professional™ 2.0.0 courseware development software was selected as a vehicle for delivery of these modules for a number of reasons. This software is available for both the Apple Macintosh and IBM-PC compatible platforms, and can be translated from the Macintosh to the PC, utilizing a large fraction of educational computing equipment already in place. This software also allows the "packaging" of programs so that the end product is self-contained. The user does not need to own the software in order to use the product. This software also has a full range of multi-media capabilities.

Navigating through the courseware is through pull-down menus and click-touch areas similar to those familiar to most students who have worked either in the Macintosh or Windows-environments. Within each section, push-button forward and backward arrows allow the students review material already presented. There is an optional "help session" available either at the beginning of a session, or at any time during the session which fully describes the use of the program. In the processing courseware, there are module-specific problems and experiments. The laboratory exercises make use of a variety of interactions including "assembly" interactions where a student is asked to drag and drop items with the mouse (either labels or pictures) to an appropriate place on the screen (sometimes in a specific order). This is extremely useful for "walking through" a lab experiment and equipment use before going in to lab. The experiments have an introduction, a background, a procedure and an analysis section, as well as information on safety and handling of the equipment and materials used.

The effectiveness of this approach is being tested this semester in an introductory materials science laboratory at Iowa State University. Students are required to complete a tutorial on the

computer before attending the laboratory. One of the major advantages over other types of pre-lab exercises (in written form, or on video tape) is the ability of the computer to provide feedback both to the student and to the professor. Built into the software is a record tracking scheme so that a professor can access a file that records which students have accessed the file and what responses were given for various interactions. This provides a unique opportunity for the instructors to learn which parts of the laboratory are most confusing to students so they can provide additional information before and during the laboratory

Sample experiment:

Twelve experiments have been developed covering various concepts in structure of materials, phase equilibria, defects and electrical, thermal, and mechanical properties. One such experiment introduces phase diagrams through the use of the Pb/Sn system. The experiment involves identifying the composition of a Pb/Sn alloy by measuring the cooling curve and consulting the phase diagram. A number of concepts are employed, including binary phase diagrams, the lever rule and the phase rule. In the computer lab-tutorial the student completes exercises which describe phase diagrams including the level rule, the amount of phases and their compositions, and the phase rule. These exercises involve the student by requiring moving labels to appropriate areas, or by pointing to correct answers or by typing responses. The student is then quizzed on various aspects of binary phase diagrams. Figure 1 shown one screen which requires the student label various parts of the phase diagram as they flash on the screen.

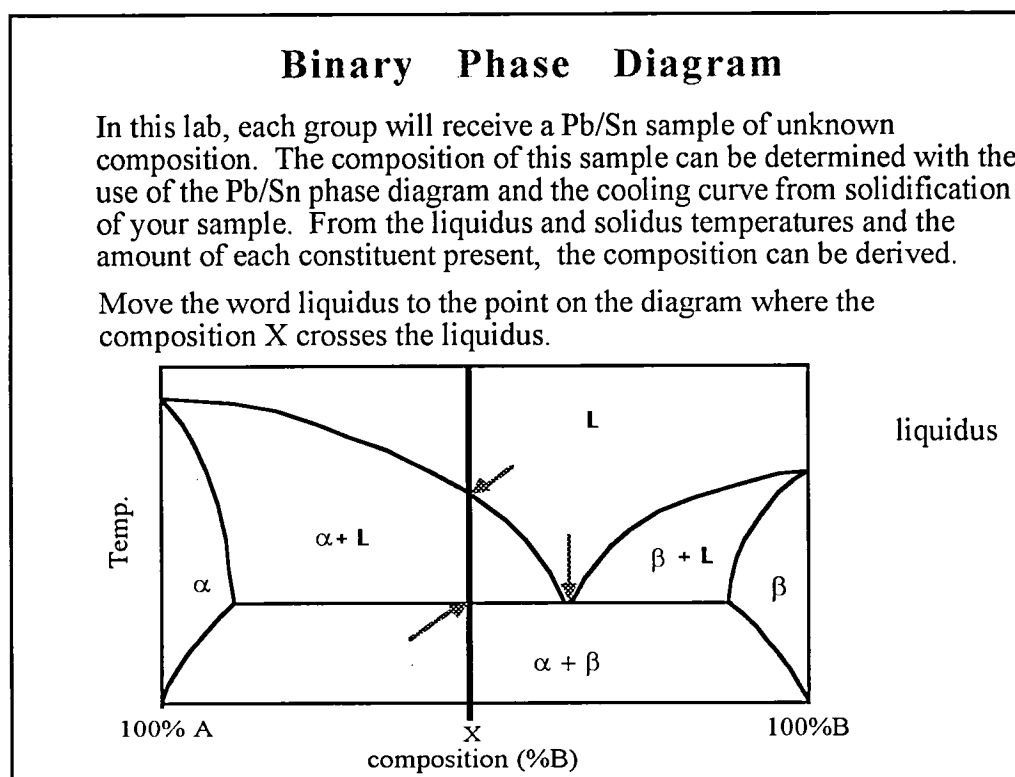


Figure 1 A screen which shows the drag and drop interaction. Students are asked to name various parts of the phase diagram.

After the introduction, the experimental procedure is reviewed. In this section, students are required to assemble the apparatus for measuring the temperature of the alloy on cooling. Students may choose to review the use of the microprocessor based controllers used in this laboratory, if necessary. (Figure 2). Finally, typical results are shown and the analysis is discussed. (Figure 3)

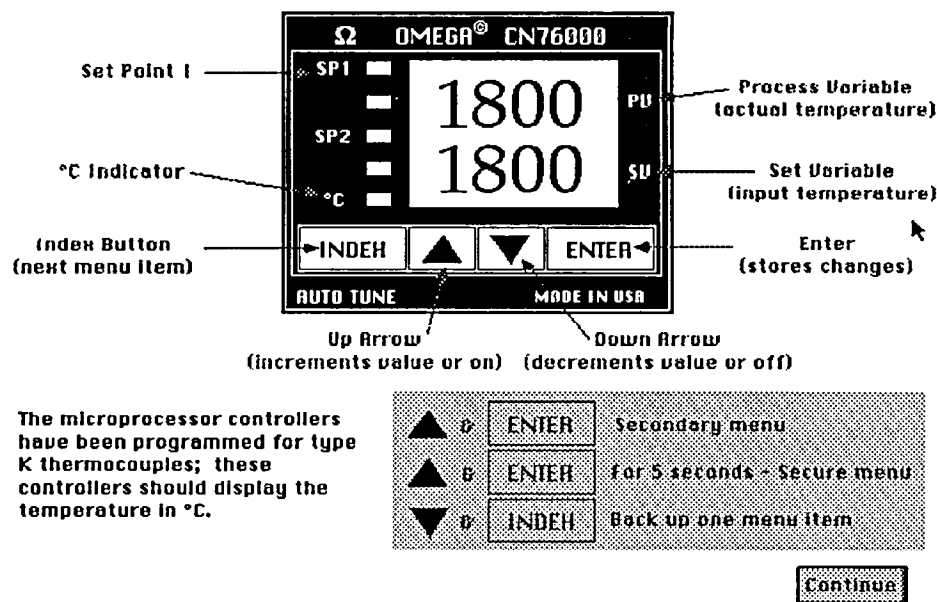


Figure 2 A screen from the tutorial on using furnace controllers.

Results

Plots similar to those outlined below can be constructed from the solidification data (assuming that T_{∞} is room temperature, $\approx 26^{\circ}\text{C}$, and T_0 is 360°C). Note that the arrows indicate a change in slope.

The points for the change in slope on the Temperature vs. time plot become more evident when lines are drawn.

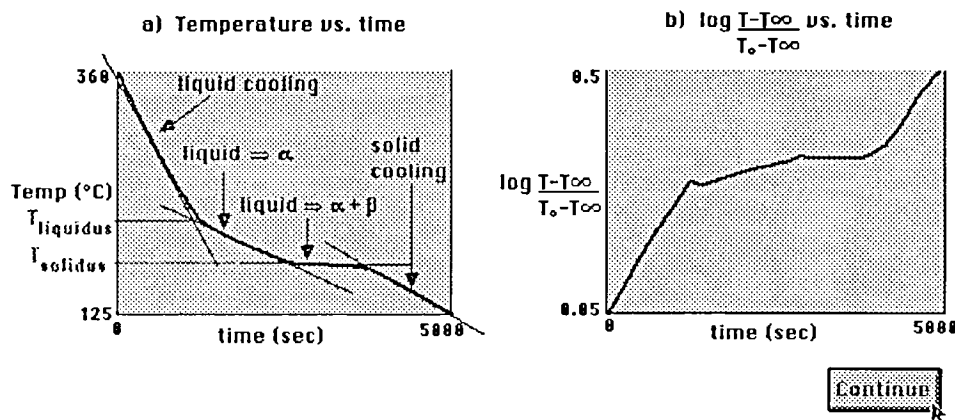


Figure 3 The Results screen shows the student typical results

Constraints and Challenges:

Dual Modes of Use

These experiment modules necessarily rely on the availability of specific equipment. Although we have made an attempt to include general equipment which is probably available in most materials science departments, it is quite likely that some of the experiments cannot be performed in some departments. We include sample results and reports for experiments which will provide some learning experience (though not hands on), for students in equipment-limited situations. In the case where equipment is available, the professor may choose to limit the students' access to the results and interpretation section to allow the student to perform these tasks alone.

Module Size

Multimedia computing can provide a rich experience of sight and sound, but can also require sophisticated hardware and large quantities of computer memory. We are attempting to limit file size and use file-compression schemes which would allow even modestly configured computers to use most, if not all of the capabilities of the modules.

Copyright issues

Although these modules will not be sold, there are copyright issues which must be considered especially for use of graphics. Since the laws relating electronic duplication and manipulation of images are not well defined, we have been keeping careful records of the sources of graphics used in these modules. We will seek guidance on these legal aspects, and seek permission when necessary.

Assessment of Effectiveness

Although it is difficult to assess the effectiveness of these lab modules in enhancing the laboratory learning experience, we hope to learn from student responses to questionnaires. We also plan to test this material at other universities and solicit suggestions for improvement.

Future Work:

Work on experimental modules will continue both improving existing modules and expanding the scope of experiments to include a broader range of advanced materials. A module involving laboratory safety is also planned.

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